COLLAPSIBLE STEERING COLUMN ASSEMBLY

FIELD OF THE INVENTION

[0001] The subject invention relates to a collapsible steering column assembly including an energy absorbing mechanism.

BACKGROUND OF THE INVENTION

[0002] Collapsible steering column assemblies are known in the art for including in vehicles to reduce the likelihood of injury to occupants of the vehicles during collisions. The steering column assemblies include a support for attachment to the vehicle. A steering column is movably supported by the support. An energy absorbing mechanism interconnects the steering column and the support for absorbing energy in response to the steering column moving relative to the support, i.e., when a force is exerted on the steering column such as during the collision.

[0003] Common energy absorbing mechanisms include a metal strap that is wrapped about an anvil. The metal strap is generally fixed to the steering column and the anvil is fixed to the support. During the collisions, when the force is exerted on the steering column, the metal strap is forced about the anvil. The metal strap resists the movement and bends about the anvil, thus absorbing the energy and allowing the steering column to move in relation to the support. One of the problems with the energy absorbing mechanisms is that the metal straps are selected to deform when a force exerted on the steering column exceeds a predetermined threshold. As a result, the energy absorbing mechanism is exhausted after absorbing the energy when the force exceeds the threshold and cannot absorb additional energy thereafter. For

example, during the collision, the force of the collision itself may exceed the predetermined threshold. In the event that the occupant impacts the steering column shortly thereafter, the energy absorbing mechanism cannot absorb any more energy. Furthermore, collisions generate forces of various magnitude on the steering column, depending on the speed of the vehicles involved, among other variables. The metal straps, chosen to deform at the predetermined threshold, are not suitable to absorb energy at forces below or substantially above the predetermined threshold. In other words, the metal straps, because of the predetermined threshold, are based on predetermined collision conditions and cannot adjust to actual collision conditions. In addition, the metal straps, once deformed, lose structural integrity and must be replaced.

[0004] Thus, there is an opportunity to provide an energy absorbing mechanism that is capable of adjustment to absorb energy at forces of various magnitude such that a universal energy absorbing device may be installed on each type of vehicle and adjusted based on individual parameters of the vehicle.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0005] The subject invention provides a collapsible steering column assembly including a support for attachment to a vehicle. A steering column is movably supported by the support. An energy absorbing mechanism interconnects the steering column and the support for absorbing energy in response to the steering column moving relative to the support during a collision. The energy absorbing mechanism includes an elongated element movable along a longitudinal axis in response to the

movement of the steering column. The energy absorbing mechanism further includes a brake for variably resisting the movement of the elongated element.

[0006] The elongated element, in combination with the brake, is capable of adjustment to absorb energy at forces of various magnitude such that a universal energy absorbing device may be installed on each type of vehicle and adjusted based on individual parameters of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0008] Figure 1 is a schematic side view of a collapsible steering column assembly including an energy absorbing mechanism prior to collapse of the assembly;

[0009] Figure 2 is another schematic side view of the collapsible steering column assembly of Figure 1 subsequent to collapse of the assembly;

[0010] Figure 3 is a partially exploded view of the assembly of Figure 1;

[0011] Figure 4 is a perspective view of a portion of a support including another embodiment of an energy absorbing mechanism; and

[0012] Figure 5 is a side view of a portion of the energy absorbing mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a collapsible steering column assembly is shown

at **10** in Figure 1. The assembly **10** is included in a vehicle for collapsing to minimize injury to occupants of the vehicle during a collision.

[0014] The collapsible steering column assembly **10** includes a support **12** for attachment to a vehicle. A steering column **14** is movably supported by the support **12**. As best shown in Figure 3, the support **12** includes a frame **16** for receiving the steering column **14**. The frame **16** defines a shape corresponding to a shape of the steering column **14**. More specifically, the steering column **14** preferably defines a box-shaped cross-section in a plane perpendicular to a longitudinal axis **L** of the steering column **14**. The steering column **14** is movable through the frame **16** along the longitudinal axis **L**. The shape of the frame **16** corresponds to the shape of the cross-section for guiding the steering column **14** as the steering column **14** moves through the frame **16**. Alternatively, the steering column **14** defines the cross-section in any variety of shapes including circular, triangular, etc.

[0015] Preferably, at least one shear capsule (not shown) is disposed between the vehicle and the steering column **14** for immobilizing the steering column **14** during normal driving conditions. During a collision, forces between the steering column **14** and the vehicle cause the shear capsule to rupture, thus releasing the steering column **14** from the immobilized position.

[0016] An energy absorbing mechanism **18** interconnects the steering column **14** and the support **12**. It is to be appreciated that the energy absorbing mechanism **18** may interconnect the steering column **14** and any part of the vehicle adjacent to and fixed with respect to the steering column **14**. The energy absorbing mechanism **18** absorbs

energy in response to the steering column **14** moving relative to the support **12** during a collision.

[0017] The energy absorbing mechanism **18** includes a elongated element **20** that is movable along a longitudinal axis **L** in response to the movement of the steering column **14**. The energy absorbing mechanism **18** further includes a brake **30** for variably resisting the movement of the elongated element **20** and absorbing the energy during the collision. By variably resisting, it is meant that the brake **30** absorbs energy at forces of various magnitude. Thus, one of the advantages of the subject invention is that the elongated element **20** is sufficiently flexible to provide insubstantial resistance to bending and, in combination with the brake **30**, is capable of adjustment to absorb energy at forces of various magnitude such that a universal energy absorbing device may be installed on each type of vehicle and adjusted based on individual parameters of the vehicle. Preferably, the elongated element **20** retains structural integrity after absorbing the energy so that the energy absorbing mechanism **18** may be returned to a pre-collision condition after absorbing the energy. Preferably, the elongated element **20** is a metal strap made of steel, but may also be made of a woven fabric, such as nylon, or any other type of material so long as the energy absorbing mechanism **18** is capable of absorbing the energy without the elongated element **20** snapping or breaking. More specifically, the elongated element **20** must be able to withstand forces of at least 300 lbs of force. In a preferred embodiment, the elongated element **20** is able to withstand forces of at least 1200 lbs of force. In addition, the elongated element **20** may have a variety of shapes. Preferably, the elongated element **20** is flat and relatively wide, having a belt or strap

shape similar to that of a seat belt strap. In another embodiment (not shown), the elongated element **20** is cable-like and has a circular cross-sectional shape. The flexible feature of the elongated element **20** means that the elongated element **20** offers negligible or no resistance to bending and merely transmits forces in tension, i.e., there is no energy absorption due to bending forces.

[0018] In one embodiment, the energy absorbing mechanism **18** includes a roller **22** rotatable about an axis **A**. Preferably, the axis **A** is transverse to the longitudinal axis **L** of the steering column **14**. The elongated element **20** has a first end **24** wound about the roller **22** for unwinding and rotating the roller **22** about the axis **A** in response to the movement of the steering column **14** relative to the support **12**. In a preferred embodiment, the roller **22** is rotatably supported by the steering column **14**. The elongated element **20** has a second end **26** fixed to the support **12**. More specifically, the elongated element **20** includes a loop at the second end **26**. The support **12** includes a fastener **28** for extending through the loop and fixing the second end **26** of the elongated element **20** to the support **12**. However, it is to be appreciated that the second end **26** of the elongated element **20** may be fixed to any other part of the vehicle adjacent to and fixed with respect to the steering column **14**. In addition, the second end **26** of the elongated element **20** may be fixed through a variety of mechanisms as are known in the art. In an alternative embodiment, as shown in Figure 4, the roller **22** is rotatably supported by the support **12**. Likewise, the roller **22** may be rotatably supported by any other part of the vehicle adjacent to and fixed with respect to the steering column **14**. The second end **26** of the elongated element

20 is fixed to the steering column **14**. The second end **26** of the elongated element **20** may be fixed through a variety of mechanisms as are known in the art.

[0019] In one embodiment, the brake **30** resists the rotational movement of the roller **22** in response to the movement of the steering column **14** relative to the support **12**. Preferably, the brake **30** is a magnetic particle brake, which is controlled by electrical signals. However, it is to be appreciated that the brake **30** may be of any variety for resisting the rotational movement of the roller **22**. In another embodiment, not shown, the brake sandwiches or otherwise frictionally engages the elongated element **20**. The brake **30** is disposed adjacent to the first end **24** of the elongated element **20**. It is to be appreciated that the brake **30** need not include the roller **22**, wherein the first end **24** of the elongated element **20** may extend for a length beyond the brake.

[0020] The brake **30** provides a control force $\mathbf{F_c}$ on the elongated element **20**, i.e., a grabbing force. Preferably, the brake **30** is operable to provide a minimum resistance such that the steering column **14** remains stable during normal operating conditions. In one embodiment, the control force $\mathbf{F_c}$ provided from the brake **30** itself is sufficient to resist the movement of the elongated element **20** and absorb the energy during the collision. In another embodiment, the steering column assembly **10** further includes at least one frictional member **32** in frictional engagement with the elongated element **20**. The frictional member **32** is disposed along the elongated element **20** between the first end **24** and the second end **26**. The frictional member **32** frictionally resists the movement of the elongated element **20** and adds to the resistance to movement of the elongated element **20** from the brake **30**. Thus, the frictional member **32** reduces the control force $\mathbf{F_c}$ required from the brake **30**. The frictional resistance depends upon a

wrap angle θ_1 of the elongated element **20** about the frictional member **32**, which relates to a contact surface area between the elongated element **20** and the frictional member **32**, and a coefficient of friction between the elongated element **20** and the frictional member **32**. Preferably, as shown in Figure 5, the elongated element **20** wraps about the frictional member **32** at an angle of from ninety to one-hundred and eighty degrees. Preferably, the coefficient of friction is up to 0.8. More preferably, the coefficient of friction is between 0.25 and 0.5. The wrap angle θ_1, the coefficient of friction, and the control force F_c provided from the brake **30** are adjusted for absorbing the energy. In a preferred embodiment, the coefficient of friction and the wrap angle θ_1 are fixed, and the control force F_c provided from the brake **30** is variable. For example, during a collision, the steering column **14** moves relative to the support **12**, which in turn moves the elongated element **20**. The brake **30** provides the control force F_c which, as described below, is variable depending on a magnitude of force **F** from the movement of the steering column **14**, while the friction between the frictional member **32** and the elongated element **20** further resists the movement of the elongated element **20**.

[0021] Preferably, the energy absorbing mechanism **18** includes the roller **22** in addition to the frictional member **32**. The frictional member **32** is adjacent and fixed in relation to the roller **22**. The brake **30** engages the roller **22** for providing the control force F_c and resisting rotational movement of the roller **22** in response to the movement of the steering column **14** relative to the support **12**. In a preferred embodiment, the energy absorbing mechanism **18** includes the roller **22** and at least two frictional members **32**, **34** in frictional engagement with the elongated element **20**

for increasing the frictional resistance to the movement of the elongated element **20**. The frictional members **32, 34** are adjacent and fixed with respect to the roller **22**. The additional frictional member **34** exponentially increases the frictional resistance to the movement of the elongated element **20**. Thus, the additional frictional member **34** corresponds to less control force $\mathbf{F_c}$ required from the brake **30**.

[0022] In one embodiment, as shown in Figure 3, the frictional members **32, 34** may be offset from each other. In another embodiment, as shown in Figure 4, the frictional members **32, 34** are disposed along a common plane. The position of the frictional members **32, 34** is adjusted to vary the wrap angle θ_1, θ_2 of the elongated element **20** about the frictional members **32, 34**. Preferably, the plane is substantially parallel with the longitudinal axis **L** of the steering column **14**. In addition, the control force $\mathbf{F_c}$ is preferably provided in a direction parallel to the direction of movement of the steering column **14**.

[0023] Preferably, as shown in Figure 1, the collapsible steering column assembly **10** includes a computer system for variably controlling the frictional resistance provided from the brake **30**. Preferably, the computer system is disposed at a remote location from the collapsible steering column assembly **10**. In a preferred embodiment, the computer system is a body computer of the vehicle that controls other functions of the vehicle as well, such as air bag deployment, and is modified to control the frictional resistance provided from the brake **30**.

[0024] The computer system comprises a sensor **36** for sensing the collision and generating signals based on a magnitude of force **F** on the steering column **14** during the collision. The computer system further includes a processor **38** for receiving the

signals from the sensor **36** and controlling the frictional resistance of the brake **30** based on the signals. More specifically, the processor **38** controls the control force $\mathbf{F_c}$ provided from the brake **30**. To tune the brake **30**, a series of forces are exerted on the steering column **14**. The sensor **36** senses the forces and generates a spectrum of signals relating to the forces. The processor **38** then relates the signals from the sensor **36** to electrical signals for controlling the brake **30**. The signals are tuned such that the control force $\mathbf{F_c}$ provided from the brake **30**, in combination with the frictional resistance provided from the frictional members **32**, **34**, substantially resists the movement of the elongated element **20** as the steering column **14** moves relative to the support **12**. Thus, the brake **30**, in combination with the computer system and the elongated element **20**, is capable of variably absorbing energy from the movement of the steering column.

[0025] In a preferred embodiment, the computer system controls the control force $\mathbf{F_c}$ provided from the brake **30** in real time. For example, the collapsible steering column assembly **10** is ordinarily in a non-collapsed position as shown in Figure 1. A first force is exerted on the steering column **14** resulting from the collision between the vehicle and another object. Based on the signals from the sensor **36**, the processor **38** controls the control force $\mathbf{F_c}$ provided from the brake **30** to resist the movement of the elongated element **20** and absorb the energy during the collision. Preferably, a minimum control force $\mathbf{F_c}$ of 300 lbs of force is provided from the brake **30**, and in order for the steering column **14** to move, the first force must be at least 300 lbs. The minimum control force $\mathbf{F_c}$ of 300 pounds force prevents movement of the steering column **14** notwithstanding a collision. Preferably, the brake **30** absorbs the energy

from the first force and prevents the steering column **14** from fully collapsing, i.e., collapsing to a position as shown in Figure 2 wherein the support **12** abuts a protruding portion **40** of the steering column **14**. Thus, the brake **30** is capable of absorbing energy from a second force after absorbing the energy from the first force. The second force may result from a collateral vehicle collision or from an occupant of the vehicle impacting the steering column **14**. The brake **30** provides the control force $\mathbf{F_c}$, and the brake **30** absorbs the energy from the second force, thus minimizing injury to the occupant. However, it is to be appreciated that the brake **30** may be capable of absorbing additional forces after the first and second forces so long as the steering column **14** is prevented from fully collapsing.

[0026] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, any modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.